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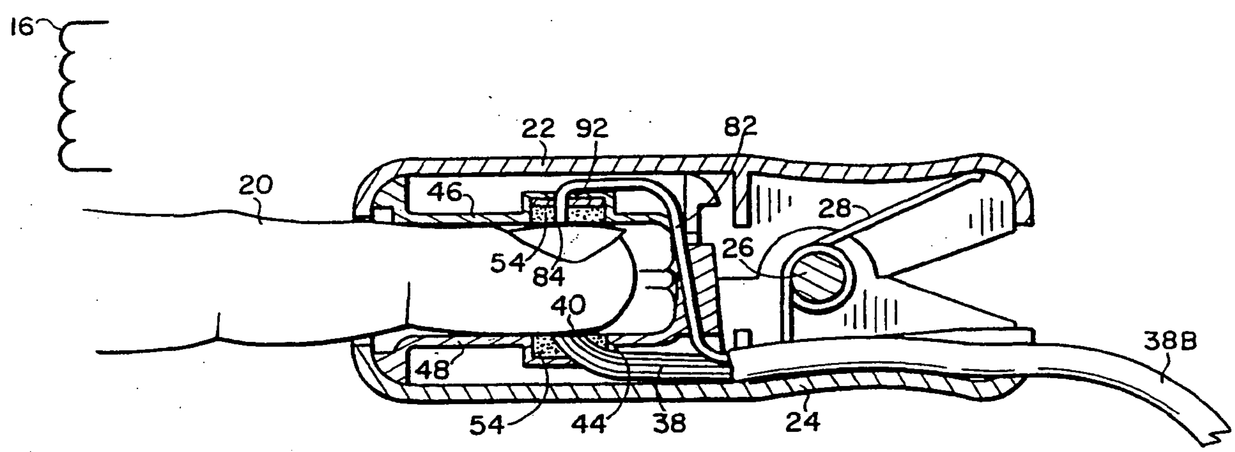

(57) Abstract

An apparatus for remotely indicating characteristics of a patient, such as blood oxygen saturation or the like, while the patient is undergoing MRI, includes a probe (18) having first and second hinged portions (22, 24) for fitting on opposite sides of a body portion, such as a finger (20) or a toe. One embodiment provides for a remotely located light source, a photodetector (60) and a pair of fiberoptic cables (38, 82), one fiberoptic cable (38) carrying light from the source to the probe (18), and the other fiberoptic cable (82) carrying light after having passed through the patient (20) to a photodetector (60) at the remote location (12). The characteristics of the patient are determined by the light having passed through the body portion of a patient, the signals transmitted by the fiberoptic cables being insensitive to MRI magnetic fields.

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APPARATUS FOR INDICATING CHARACTERISTICS OF A PATIENT UNDERGOING MRI

Cross-referenc To the Existing Application

This is a continuation-in-part of application No. 07/708,982 filed May 31, 1991 entitled "Apparatus For Indicating Characteristics Of A Patient Undergoing MRI".

Summary of the Invention

An important technique utilized in medicine for investigating conditions of the human body includes the use of Magnetic Resonance Imaging (MRI). Typically, the patient is placed supine on a moveable, horizontal table which moves through a field wherein the patient is subjected to rapidly changing, intense R.F. (Radio Frequency) electric and magnetic fields. The nuclear resonance produced by the rapidly changing fields is detected and by computer analysis detailed information of the interior of the human body can be obtained which, in many instances, is more detailed than that available from X-ray and simultaneously at less patient detriment than is occasioned by the use of X-ray. Since, obviously, most patients undergoing MRI may be ill for one reason or another and since subjecting a patient to the environment to which MRI signals are derived can be problematic, it is highly desirable that the physical state of the patient be constantly monitored.

An instrument that is commonly used for monitoring patients is an oximeter. Oximeters provide information as to the patient's blood flow characteristics, such as the blood oxygen saturation and pulse rate. Oximeters are currently available on the market and function successfully in the normal doctor's office or operating room wherein intense R.F. and magnetic fields do not exist. The typical oximeter includes a probe attached to a patient's body portion, such as to the patient's finger, with conductors extending from the probe to instrumentation. Within the probe of the

currently available oximeter is a light source, such as light emitting diodes and a photodetector, the light source and detector being placed on opposite sides of the patient's body portion, such as the patient's finger. Signals generated by the photodetector are carried by conductors to circuitry wherein the blood flow characteristics are determined and indicated. This system works very successfully in normal environments. However, in an MRI environment electrical voltage signals are induced in the conductors extending from the probe to the oximeter. These voltages can induce currents which interfere with the oximeter, as well as produce risk of R.F. burn to the patient. Also, the electronic logic within the oximeter can place distorting "noises" onto the MRI images. For these reasons, the use of readily available non-invasive oximeters for patients undergoing MRI has met limited success.

An object of this disclosure is to provide an oximeter that can be used on a patient undergoing MRI or otherwise used in an area of large R.F. and/or magnetic fields and wherein the debilitating effects of the large fields do not deteriorate the effectiveness and reliability of the oximetry measurements while providing distortion free MRI imaging.

For information relating to similar problems of improving the quality of electrocardiograms obtained from patients undergoing MRI, reference may be had to United States Patent No. 4,991,580 issued February 12, 1991.

For reference to pulse oximeter monitors of the type typically employed in environments wherein large or rapidly changing fields are not a problem, reference may be had to the following United States Patents: 3,412,729; 3,647,299; 3,638,640; 4,222,389 and 4,653,498. These are merely exemplary of a large number of patents and other publications that have been issued on non-invasive blood oximeter techniques.

The present disclosure is for an apparatus for indicating characteristics of a patient undergoing MRI in which the patient is exposed to high intensity changing R.F. and magnetic fields. The characteristics of the patient are determined by one or more beams of light through a body portion of the patient. Typically, the characteristics determined are blood oxygen saturation and pulse rate.

These characteristics are determined by generating a light directed for passing through a patient's body portion. A probe having a first portion and a second portion is adapted for fitting against opposed surfaces of a body portion of a patient, such as a finger. Optionally, the two portions may be located adjacent one another for operation in a reflective or scattered light oximeter mode. The means for generating light preferably includes light emitting diodes within one of the probe portions or conducted thereto via optical fibers.

An elongated fiberoptic cable has a first and a second end. The first end is juxtaposed to the patient's body portion for receiving light from the light generating source passing through the patient's body portion. This first end of the fiberoptic cable may be positioned within a finger probe second portion and affixed for receiving light passing through the patient's finger. The second end of the fiberoptic cable is remote from the patient and in an area of reduced R.F. and magnetic fields. Located in such remote area is a circuit having, as a part thereof, a photodetector, such as a photodiode, that is juxtaposed to the fiberoptic cable second end. The photodetector has output leads. A circuit, having an indicator, is connected to the photodetector output leads for determining the patient's characteristics, such as blood oxygen saturation, pulse rate or the like. An indicator discloses these measured characteristics of the patient to medical personnel.

By the use of an elongated fiberoptic cable, the photodetector and the circuit used therewith, can be remotely located from the patient. The fiberoptic cable that carries the optical signal is not subjected to the effects of the rapidly changing R.F. and magnetic fields caused by MRI -- that is, the fiberoptic cable is essentially non-electrically conductive and is therefore not substantially effected by exposure to R.F. and magnetic fields as produced by MRI. Instead, the fiberoptic cable transmits light that is passed through the patient's body portion in a highly efficient manner to the photodiode and other circuitry components located in an area remote from the patient and in an area wherein the effect of the high intensity R.F. and magnetic fields is substantially reduced. In this manner, the patient's body characteristics can be determined and displayed to operating personnel efficiency and effectively and without the deleterious effect normally encountered when using typical electronic equipment on a patient undergoing MRI. Optionally, the light generating source required may be transmitted from the remote location to the patient via optical fibers. Transmission of the light source via the optical fibers may be avoided where the source illumination itself can be chosen or designed to be free of the deleterious effects of R.F. and magnetic fields, and where such source placement can be made so as to have little risk of coupling burning R.F. currents onto the subject patient and where the source drive can be properly filtered so that MRI imagine degrading noise is removed.

In another arrangement which is even less effected by the R.F. and magnetic fields typically encountered by a patient undergoing MRI, an embodiment is provided wherein all of the communication between the probe and the remotely located instrumentation is carried out using fiberoptic cables. That is, in the alternate system no electric current carrying conductor is required to extend between the probe and the controlling circuitry.

In the alternate embodiment there is a first and a second fiberoptic cable. The second cable functions as has been described, that is, one end of the second cable is contoured to fit against a person's body part and the other end is in engagement with a photodetector remotely located from the patient. In this new embodiment there is also provided a first fiberoptic cable, most of the length of which can be encompassed in a sheath with the second fiberoptic cable. The first fiberoptic cable has opposed ends, one end being contoured to engage the body portion of a patient undergoing MRI. The other end of the first fiberoptic cable is attached to a photodiode or other similar light emitting source, and is preferably placed in the same instrumentation with the photodetector. In this manner, light is generated and ultimately received in instrumentation which is remotely located from the patient and in an area of substantially reduced R.F. and magnetic fields.

The probe employed is essentially the same as that heretofore described except that the probe first portion receives the first end of the first fiberoptic cable which is bent in an arcuate curve adjacent the first end thereof so as to position the first end in contact with the patient's body portion.

The alternate embodiment may also employ the arrangement wherein the first fiberoptic cable is in the form of two parallel parts so that two different light frequencies may be alternately transmitted to pass through the patient. In such an arrangement the bundle of fiberoptic cables consists of three portions, that is, part A and part B of the first portion which transmits two different light frequencies from remotely located instrumentation; and the second fiberoptic cable which transmits light from the patient back to the remotely located instrumentation, the light having passed through a body portion of a patient. In the instrumentation the light is converted into electric signals by a photodetector.

For a better understanding of the invention of this disclosure, reference is now had to the following specification and claims, taken in conjunction with the attached drawings.

Description of the Drawings

Figure 1 is a diagrammatic representation of the use of an apparatus for indicating characteristics of a patient undergoing magnetic resonance imaging (MRI) and specifically, wherein the characteristic to be determined is blood oxygen saturation and pulse rate. The right portion of Figure 1 shows a finger probe as used to attach to the patient, whereas the left-hand portion of Figure 1 shows oximetry equipment for use in determining the patient's blood oxygen saturation and pulse rate and for displaying such information. The right-hand portion of Figure 1 is separated from the left-hand portion by an elongated fiberoptic cable so that the right-hand portion of Figure 1 is in an area of rapidly changing, intense R.F. and magnetic fields and the left-hand portion is in an area remote from the patient and in an area of reduced MRI produced changing R.F. and magnetic fields.

Figure 2 is an enlarged cross-sectional view of the finger probe as in Figure 1 positioned on the finger of a patient, such as a patient undergoing MRI.

Figure 3 is a cross-sectional view of a finger probe, as in Figure 2, positioned on the finger of a patient, such as a patient undergoing MRI, illustrating the alternate embodiment wherein light is both transmitted to and away from the patient by means of fiberoptic cables, thereby eliminating any current carrying conductor between the probe and the instrumentation.

Figure 4 is a diagrammatic view of the arrangement of Figure 3 showing a fiberoptic cable package having a first and second fiberoptic cable. The first cable transmits light from a remote location, such as generated by a light emitting diode, to the probe. In the probe the first fiberoptic cable is bent and contoured to engage the patient's body portion. One end of the second fiberoptic cable is received within the

probe and is bent and contoured to engage the opposite side of the patient's body portion to receive light having passed therethrough. The opposite end of the second fiberoptic cable has attached to it a photodetector that converts the light into an electric signal that is analyzed for indicating the patient's body characteristics.

Figure 5 is a fragmentary view of one end of the cable package system as shown in Figure 4 illustrating the use of three fiberoptic cables, two for transmitting light of different frequencies and one for transmitting light having passed through the patient's body portion back to remotely located instrumentation.

Description Of The Pref rred Embodiments

This invention relates broadly to an apparatus for indicating characteristics of a patient undergoing Magnetic Resonance Imaging (MRI) in which the patient is exposed to changing high intensity R.F. and magnetic fields produced by the MRI and in which the characteristics of the patient are determined by passage of one or more beams of light through a body portion of the patient. As a specific example of the application of the principles of this invention, it will be described as it specifically relates to a non-invasive blood oximeter of the type having a finger probe and an indicating instrument.

An oximeter determines a patient's arterial blood oxygen saturation (SaO_2) by measuring the absorption of two selected wavelengths of light. The light generated in the sensor (probe) passes through the blood and tissue and is converted into electronic signals by a photodetector.

Blood hemoglobin exists in two principle forms: HbO_2 (oxygenated, with O_2 molecules loosely bound) and Hb (reduced, with no molecules bound). Arterial blood oxygen saturation is the ratio of oxygenated hemoglobin to total hemoglobin, and can be expressed by the formula:

$$SaO_2 = \frac{HbO_2}{HbO_2 + Hb}$$

Since HbO_2 and Hb allow different amounts of light at selected wavelengths to reach the photodetector, the electronic signals vary in relation to both the amount of blood present in the tissue (the pulse waveform) and the amount of HbO_2 in the blood.

In the monitor, the signals are amplified and filtered so that artifacts from motion and ambient room light are discarded. The signals that remain are those from the arterial blood. Processing of the signal then provides information that can be used such as for numeric display of SaO_2 and pulse rate as well as other uses, such as display of pulse strength on a light bar and storage of data in memory for trend indications.

Referring to Figure 1, the figure is divided into a right-hand portion 10 and a left-hand portion 12 by a dividing line 14. The right-hand portion 10 is in an area of R.F. and intense magnetic fields, exemplified by an electromagnetic coil 16 indicative of a MRI installation. Due to the high intense fields in area 10, electrical instruments that include electrical conductors experience difficulty since the rapidly changing magnetic and R.F. fields can induce electrical voltages within the conductors. The present device reduces this problem as it pertains, by way of example, to an oximeter. The left portion 12 is in an area remote from that of area 10 and has reduced R.F. and magnetic field intensities and represents those circuits of portion 12 which may not be within the MRI scanner bore.

Within right portion 10 of Figure 1 is an oximeter finger probe, generally indicated by the numeral 18 and which is illustrated in Figure 2 in cross-sectional view. In Figure 2 the finger 20 of a patient is positioned within the probe, and the probe is in closed position, whereas in Figure 1 the probe is disassembled for illustration of some of the basic components making up the probe.

The probe 18 includes a first portion 22 and a second portion 24, the portions being pivoted together about a pin 26. A spring 28 normally holds the portions closed. The portions are in the old-fashioned "clothespin" arrangement so that the rearward portion may be manually squeezed to pivot the forward portion open to receive finger

20 of a patient. Positioned within the finger probe first portion 22 is a light emission source, such as light emitting diodes, and particularly and preferably a pair of light emitting diodes 30 and 32. The diodes 30 and 32 emit light of different frequencies and in pulsed arrangement. A R.F. squelching capacitor 34 is positioned in parallel with diodes 30 and 32. A conductor 36 supplies electrical energy to sequentially pulse the diodes to generate light of two different frequencies.

An elongated fiberoptic cable is an integral and important part of the apparatus. The fiberoptic cable is indicated by the numeral 38 and is typically surrounded with a rubber jacket 38A so that the numeral 38A indicates the rubber jacketed fiberoptic cable. The fiberoptic cable 38 has a first end 40 received within finger probe 18 and a second end 42, as seen in the left portion 12 of Figure 1.

Referring back to Figure 2, the fiberoptic cable is bent at 44 and the end surface 40 is contoured to engage finger 20 of the patient.

In probe 18 a pillow type arrangement, identified by the numeral 46, that may be filled with silicon rubber, is used to support light emitting diodes 30 and 32, and in the finger probe second portion 24 a similar pillow 48 supports end 40 of fiberoptic cable 38. Pillow 48 has a recess 50 therein and the end portion of the fiberoptic cable adjacent the end 40 is retained within recess 50 in the pillow, such by means of potting compound 52.

As seen in Figure 2, the light emitting diodes 30 and 32 are preferably supported in an insulating light transmitting potting compound 54 within a pocket in pillow 46, and the light transmitting potting compound having diodes 30 and 32 is in contact with the patient's fingernail 56. The potting compound is chosen to both inhibit RF coupling and promote light transmission to the subject. The fiberoptic cable first end 40 is in contact with the patient's finger opposite fingernail 56 so that light emitted by diodes

30 and 32 passes through the patient's finger and enters the fiberoptic cable at first end 40.

The rubber mounted fiberoptic cable 38A extends to a sensor filter chassis 58. Mounted within the chassis in juxtaposed, that is contiguous, contact with the fiberoptic cable second end 42 is a photodetector 60 that may be in the form of a photodiode. The photodetector has output leads 62.

Referring back to Figure 2, conductor 36 that is used to activate the light emitting diodes 30 and 32 is mounted within rubber covering 38A surrounding fiberoptic cable 38. Conductor 36 emerges from within cable rubber jacket 38A adjacent sensor filter chassis 58, as shown in Figure 1. The leads of cable 38 pass through a tuned ferrite shielding bead 64 and then enter and transverse the sensor filter chassis 58 via a series of feed through filter capacitors and R.F. chokes which remove oximeter logic and electronic interference as well as MRI induced R.F. signals.

A cable 66 extends from the sensor filter chassis 58 to an oximeter logic and electronics housing 68 whereon indications of the measured body characteristics are displayed. For instance, in housing 68 blood oxygen saturation may be shown in window 70, such as by a liquid crystal display or the like. The patient's pulse rate may be shown in the window 72. A pulse track light bar 74 may also be of the liquid crystal display type that varies in height with pulse and signal strength. Other features may be employed in blood oximeter housing 68, such as a system status display 76. The oximeter also typically includes other features such as an "on" and "off" switch 78, at least one alarm system control 80, and so forth, that are exemplary of a typical state of the art oximeter.

As previously described, the essence of this invention is a system that employs a fiberoptic cable for coupling light to a remote area wherein the light is used as a

means of measuring the characteristics of a patient, such as blood oxygen saturation, pulse rate or the like. The high intensity R.F. and magnetic fields in the area wherein the patient is positioned (MRI bore) and where the body characteristics must be measured do not deleteriously effect light as transmitted by the fiberoptic cable. That is, the fiberoptic cable is essentially non-electrically conductive and therefore is not significantly effected by the MRI magnetic and R.F. fields. The high intensity fields will effect conductor 36, however, this conductor is used only for pulsing light emitting diodes 30, 32, and conductor 36 is not involved with the sensitive received signal used to indicate the actual body characteristics. Thus, the effect of the high intensity R.F. and magnetic fields on conductor 36 is substantially harmless and this can be accommodated by means of potting 54, LED placement, the use of the R.F. squelching capacitor 34, as shown in Figure 2, and so forth. The imaging degrading noise produced by the oximeter logic and electronics 68 are controlled by the sensor filter chassis 58, as shown in Figure 1.

Referring to Figures 3 and 4 an alternate embodiment of the invention is illustrated. In this embodiment light is generated and transmitted from a remote location area 12 to the probe. This technique eliminates the need for an electrical conductor as is employed in the embodiment of Figures 1 and 2. Referring first to Figure 4, a diagrammatic illustration, there is shown, in addition to fiberoptic cable 38, a first fiberoptic cable 82. The first fiberoptic cable 82 has a first end 84 and a second end 86. Secured at the second end 86 is a light emitting diode assembly 88 controlled by conductors 90. Light to be passed through the body portion of a patient is generated by the light emitting diode assembly 88 and flows through first fiberoptic cable 82 to the first end 84. Within the probe first portion 22 the first fiberoptic cable 82 has an arcuate curve 92 therein so that the first end 84 is positioned to engage the

body portion of the patient. Fiberoptic cables 38 and 82 are preferably bundled together in a sheath 38B to extend the fiberoptic cable from the probe to the instrumentation that is positioned within remote area 12. Figure 3 shows the way the first fiberoptic cable 82 is positioned within first probe portion 22. The first fiberoptic cable is bent in an arcuate curve 92 to pass through the pillow portion 46 and is supported in position by potting material 54, as described with reference to Figure 2. In this manner, first end 84 of the first fiberoptic cable is held into intimate contact with the patient's body portion, such as a patient's fingernail. The second cable portion 38 functions in the same way as described with reference to Figures 1 and 2. In the remote instrumentation area 12 the second end 42 of fiberoptic cable 38 engages a photodetector 60 that converts light from fiberoptic cable 38 into electrical signals that appear on conductors 62. These signals are carried to instrumentation as previously described for indicating the characteristics of the patient.

In the typical application of this invention fiberoptic cable 38 has, by example, a diameter of .125 inches, whereas first fiberoptic cable 82 has a diameter of only .05 inches. Each of the fiberoptic cables is made up of a bundle of very small diameter light transmitting strands. First fiberoptic cable 82 can be of relatively small diameter since it carries light from light emitting diode 88 with a high degree of efficiency, that is, very little light is lost in transmittal and therefore a relatively small cable is required to transmit sufficient light for passage through a patient's body portion. Cable 38 must be of larger diameter since relatively weak, low intensity light is transmitted through the patient's body portion and therefore larger light gathering and transmitting characteristics are required for cable 38.

Figure 5 shows a fragmentary view of a slightly altered embodiment. As has been previously described in the preferred arrangement for detecting the

characteristics of a patient undergoing MRI, it is desirable that light of two different frequencies be transmitted through the patient's body portion. In the embodiment of Figures 1 and 2 this is accomplished by two separate photodiodes positioned within the probe first portion. The photodiodes are energized by current carried to the probe by the electrical conductor. The advantages of two light frequencies can be obtained without the use of electrical conductors by employing separate fiberoptic cables for delivering light to the probe. In this arrangement, each portion of the first cable has a light emitting diode in the instrumentation section as shown in Figure 5, the first light emitting diode being indicated by the numeral 88 and the second light emitting diod being indicated by the numeral 94. Since, as has been discussed before, the bundle of fiberoptic strands required to transmit light are relatively small and need only be about .05 inches in diameter, two of such bundles can easily be carried along with cable 38 and encompassed in sheath 38C. Light of two different frequencies, preferably alternately energized, can be employed for passing through the body portion of the patient to more effectively determined the patient's characteristics, such as blood oxygen saturation.

The claims and the specification describe the invention presented and the terms that are employed in the claims draw their meaning from the use of such terms in the specification. The same terms employed in the prior art may be broader in meaning than specifically employed herein. Whenever there is a question between the broader definition of such terms used in the prior art and the more specific use of the terms herein, the more specific meaning is meant.

While the invention has been described with a certain degree of particularity, it is manifest that many changes may be made in the details of construction and the arrangement of components without departing from the spirit and scope of this

disclosure. It is understood that the invention is not limited to the embodiments set forth herein for purposes of exemplification, but is to be limited only by the scope of the attached claim or claims, including the full range of equivalency to which each element thereof is entitled.

What is claimed:

1. An apparatus for indicating the characteristics of a patient, such as blood oxygen saturation, pulse rate or the like, comprising:

a probe having a first portion and a second portion, the second portion being hinged to the first portion about a hinge axis, the probe portions being spreadable apart for fitting against opposed surfaces of a body portion of a patient;

a remotely located light emitting source for providing pulses of light;

a first elongated fiberoptic cable having a first end and a second end, the first end being received in said first probe portion and positioned to provide light directed to pass through a body portion of a patient, the second end being positioned to receive pulses of light from said remotely located light emitting source;

a remotely located sensor apparatus having a photodetector with output leads therein;

a second elongated fiberoptic cable having a first end and a second end, the first end being received in said second probe portion and positioned for receiving light having passed through a body portion of a patient from said first fiberoptic cable, the second cable second end being positioned in said remotely located sensor apparatus and having optical continuity with said photodetector in said remotely located sensor apparatus; and

circuit means within said remotely located sensor apparatus having indicator means connected to said photodetector output leads for determining the patient's characteristics in response to light passing through the patient's

body portion as conveyed to said photodetector by said second fiberoptic cable.

2. An apparatus for indicating characteristics of a patient according to claim 1 wherein said first fiberoptic cable is bent about 90 degrees in an arcuate curve within said probe first portion and wherein said first fiberoptic cable first end is contoured adjacent to said arcuate curve to make intimate contact with the body portion of a patient, and wherein said second fiberoptic cable is bent about 90 degrees in an arcuate curve within said second probe portion and wherein said second fiberoptic cable first end is contoured adjacent to said arcuate curve to make intimate contact with the body portion of a patient.

3. An apparatus for indicating characteristics of a patient according to claim 2 including:

resilient pillow means positioned within said probe first and second portions, said fiberoptic cables extending through said resilient pillow means to make intimate contact with the body portion of a patient.

4. An apparatus for indicating characteristics of a patient according to claim 3 wherein said fiberoptic cables are each retained within said resilient pillow means by potting compound.

5. An apparatus for indicating characteristics of a patient undergoing magnetic resonance imagining (MRI) in which the patient is exposed to changing R.F. and magnetic fields produced by the MRI and in which the characteristics are

determinable by passage of a beam of light through a body portion of the patient, the apparatus comprising:

a probe having a first portion and a second portion, the second portion being hinged to the first portion about a hinge axis, the probe portions being spreadable apart for fitting against opposed surfaces of a body portion of a patient;

a remotely located light emitting source for providing pulses of light, the light emitting source being remote from the patient and in an area of reduced R.F. and MRI produced changing magnetic fields;

a first elongated fiberoptic cable having a first end and a second end, the first end being received in said first probe portion and positioned to provide light directed to pass through a body portion of a patient, the second end being positioned to receive pulses of light from said remotely located light emitting source;

a remotely located sensor apparatus having a photodetector with output leads, the sensor apparatus being remote from the patient and in an area of reduced R.F. and MRI produced changing magnetic fields;

a second elongated fiberoptic cable having a first end and a second end, the first end being received in said second probe portion and positioned for receiving light having passed through a body portion of a patient from said first fiberoptic cable, the second cable second end having optical continuity with said photodetector in said remotely located sensor apparatus; and

remotely located circuit means having indicator means connected to said photodetector output leads for determining the patient's characteristics in response to light passing through the patient's body portion as conveyed to

said photodetector in said remotely located sensor apparatus by said second fiberoptic cable, the circuit means being remote from the patient and in an area of reduced R.F. and MRI produced changing magnetic fields.

6. An apparatus for indicating characteristics of a patient undergoing magnetic resonance imaging according to claim 5 wherein said light emitting means includes means of sequentially pulsing light of a plurality of selected wavelengths.

7. An apparatus for indicating characteristics of a patient undergoing magnetic resonance imaging according to claim 6 wherein said first and second fiberoptic cables are each bent about 90 degrees in an arcuate curve within said probe first and second portions respectively and wherein first said fiberoptic cable first end is contoured adjacent said arcuate curve to make intimate contact with the body portion of a patient, and wherein said second fiberoptic cable first end is contoured adjacent said arcuate curve to make intimate contact with the body portion of a patient.

8. An apparatus for indicating characteristics of a patient undergoing magnetic resonance imaging according to claim 7 wherein said light emitting means is in the form of a first and a second light emitting diodes.

9. An apparatus for indicating characteristics of a patient, such as blood oxygen saturation, pulse rate or the like, comprising:

a probe having a first probe portion and a second probe portion, the

second probe portion being hinged to the first portion about a hinge pin, the probe portions being spreadable apart for fitting against opposed surfaces of a body portion of a patient;

light emitting means within said first probe portion for providing light directed to pass through a body portion of a patient;

a remotely located sensor apparatus having a photodetector with output leads therein;

an elongated fiberoptic cable having a first end and a second end, the first end being received in said second probe portion and positioned for receiving light having passed through a body portion of a patient from said light emitting means, the cable second end having optical continuity with said photodetector in said sensor apparatus; and

circuit means having indicator means connected to said photodetector output leads for determining the patient's characteristics in response to light passing through the patient's body portion as conveyed to said photodetector by said fiberoptic cable.

10. An apparatus according to claim 9 wherein said light emitting means includes means of sequentially pulsing light of a plurality of selected wavelengths.

11. An apparatus according to claim 9 wherein said fiberoptic cable is bent about 90° in an arcuate curve within said probe second portion and wherein said fiberoptic cable first end is contoured adjacent said arcuate curve to make intimate contact with the body portion of a patient.

12. An apparatus according to claim 9 wherein said fiberoptic cable is bent within said probe second portion and wherein said fiberoptic cable first end is contoured to make intimate contact with the body portion of a patient.

13. An apparatus according to claim 9 wherein said light emitting means is in the form of two light emitting diodes with an R.F. squelching capacitor in parallel therewith.

14. An apparatus according to claim 9 wherein said circuit means includes means for energizing said light emitting means having connection to said sensor apparatus, including:

an electrical conductor extending from said sensor apparatus to said light emitting means within said probe first portion.

15. An apparatus according to claim 12 including:

resilient pillow means positioned within said probe second portion, said fiberoptic cable extending through said resilient pillow means to make intimate contact with the body portion of a patient.

16. An apparatus according to claim 15 wherein said fiberoptic cable is retained within said resilient pillow means by potting compound.

17. An apparatus according to claim 10 including:

resilient pillow means positioned within said probe first portion, said light emitting means being supported by said pillow means to thereby hold said light emitting means in intimate contact with the body portion of a patient.

18. An apparatus for indicating characteristics of a patient undergoing magnetic resonance imaging (MRI) in which the patient is exposed to changing R.F. and magnetic fields produced by the MRI and in which the characteristics are determinable by passage of one or more beams of light through a body portion of the patient, the apparatus comprising:

a probe having a first probe portion and a second probe portion, the second probe portion being hinged to the first probe portion about a hinge pin, the portions being spreadable apart for fitting against opposed surfaces of a body portion of a patient;

light emitting means within said first probe portion for providing light directed to pass through a body portion of a patient;

a remotely located sensor apparatus having a photodetector with output leads therein, the sensor apparatus being remote from the patient and in an area of reduced R.F. and MRI produced changing magnetic fields;

an elongated fiberoptic cable having a first end and a second end, the first end being received in said second probe portion and positioned for receiving light having passed through a body portion of a patient from said light emitting means, the cable second end having optical continuity with said photodetector in said remote sensor apparatus; and

circuit means having indicator means connected to said photodetector output leads for determining the patient's characteristics in response to light passing through the patient's body portion as conveyed to said photodetector in said remotely located sensor apparatus by said fiberoptic cable.

19. An apparatus according to claim 11 wherein said light emitting means includes means of sequentially pulsing light of a plurality of selected wavelengths.

20. An apparatus according to claim 18 wherein said fiberoptic cable is bent about 90° in an arcuate curve within said probe second portion and wherein said fiberoptic cable first end is contoured adjacent said arcuate curve to make intimate contact with the body portion of a patient.

21. An apparatus according to claim 18 wherein said light emitting means is in the form of two light emitting diodes with an R.F. squelching capacitor in parallel therewith.

22. An apparatus according to claim 10 wherein said circuit means includes means for energizing said light emitting means having connection to said sensor apparatus, including:

an electrical conductor extending from said sensor apparatus to said light emitting means within said probe first portion.

AMENDED CLAIMS

[received by the International Bureau on 17 November 1992 (17.11.92); original claims 1,2,9-22 deleted; original claims 3,4 amended; new claims 23 and 24 added; remaining claims unchanged (4 pages9]

body portion as conveyed to said photodetector by said second fiberoptic cable.

(Cancel)2. An apparatus for indicating characteristics of a patient according to claim 1 wherein said first fiberoptic cable is bent about 90 degrees in an arcuate curve within said probe first portion and wherein said first fiberoptic cable first end is contoured adjacent to said arcuate curve to make intimate contact with the body portion of a patient, and wherein said second fiberoptic cable is bent about 90 degrees in an arcuate curve within said second probe portion and wherein said second fiberoptic cable first end is contoured adjacent to said arcuate curve to make intimate contact with the body portion of a patient.

3. An apparatus for indicating characteristics of a patient according to claim 23 including:

resilient pillow means positioned within said probe first and second portions, said fiberoptic cables extending through said resilient pillow means to make intimate contact with the body portion of a patient.

4. An apparatus for indicating characteristics of a patient according to claim 23 wherein said fiberoptic cables are each retained within said resilient pillow means by potting compound.

5. An apparatus for indicating characteristics of a patient undergoing magnetic resonance imagining (MRI) in which the patient is exposed to changing R.F. and magnetic fields produced by the MRI and in which the characteristics are

fiberoptic cable, the circuit means being remote from the patient and in an area of reduced R.F. and MRI produced changing magnetic fields.

6. An apparatus for indicating characteristics of a patient undergoing magnetic resonance imaging according to claim 5 wherein said light emitting means includes means of sequentially pulsing light of a plurality of selected wavelengths.

7. An apparatus for indicating characteristics of a patient undergoing magnetic resonance imaging according to claim 6 wherein said first and second fiberoptic cables are each bent about 90 degrees in an arcuate curve within said probe first and second portions respectively and wherein first said fiberoptic cable first end is contoured adjacent said arcuate curve to make intimate contact with the body portion of a patient, and wherein said second fiberoptic cable first end is contoured adjacent said arcuate curve to make intimate contact with the body portion of a patient.

8. An apparatus for indicating characteristics of a patient undergoing magnetic resonance imaging according to claim 7 wherein said light emitting means is in the form of a first and a second light emitting diodes.

(Cancel)9. An apparatus for indicating characteristics of a patient, such as blood oxygen saturation, pulse rate or the like, comprising:

a probe having a first probe portion and a second probe portion, the second probe portion being hinged to the first portion about a hinge pin, the

23. An apparatus for indicating the characteristics of a patient, such as blood oxygen saturation or pulse rate, comprising:

a probe having a first portion and a second portion, the second portion being hinged to the first portion about a hinge axis, the probe portions being spreadable apart for fitting against opposed surfaces of a body portion of a patient;

a remotely located light emitting source for providing pulses of light;

a first elongated fiberoptic cable having a first end and a second end, the first end being received in said first probe portion and being bent about 90 degrees in an arcuate curve within the first probe portion so that the first end is positioned to contact a body portion of a patient to provide light directed to pass through the body portion, the second end being positioned to receive pulses of light from said remotely located light emitting source;

a remotely located sensor apparatus having a photodetector with output leads therein;

a second elongated fiberoptic cable having a first end and a second end, the first end being received in said second probe portion and being bent about 90 degrees in an arcuate curve within said probe second portion, and the first end being contoured adjacent the arcuate curve to make intimate contact with the body portion of a patient for receiving light having passed through a body portion of a patient from said first fiberoptic cable, the second cable second end being positioned in said remotely located sensor apparatus and having optical continuity with said photodetector in said remotely located sensor apparatus; and

circuit means within said remotely located sensor apparatus having indicator means connected to said photodetector output leads for determining the patient's characteristics in response to light passing through the patient's body portion as conveyed to said photodetector by said second fiberoptic cable.

24. An apparatus for indicating characteristics of a patient according to claim 23 including:

resilient pillow means positioned within said probe first and second portions for abutting with a patient's body portion, said fiberoptic cables extending through said resilient pillow means to make intimate contact with the body portion of a patient.

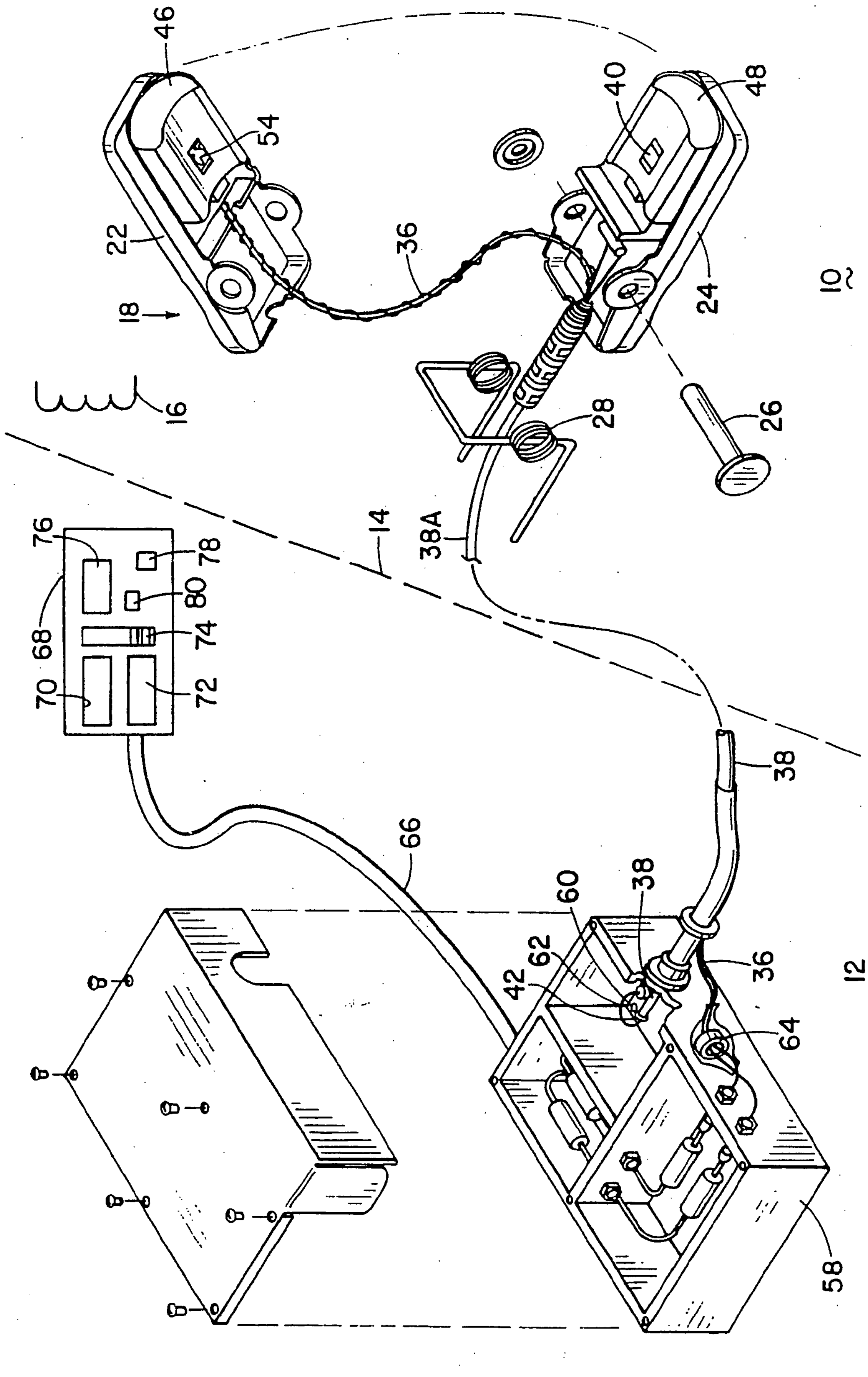
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Fig. 1

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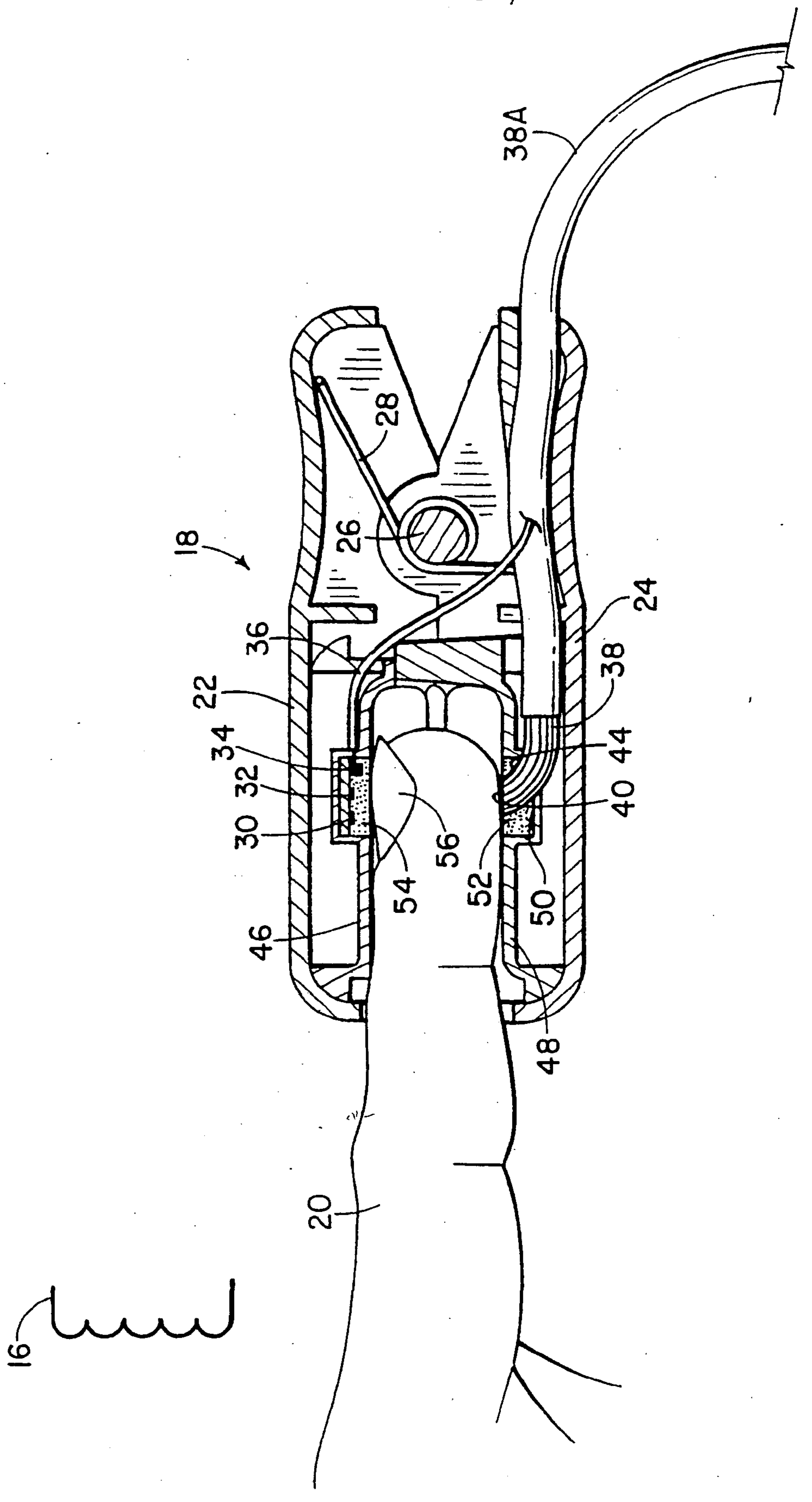

Fig. 2

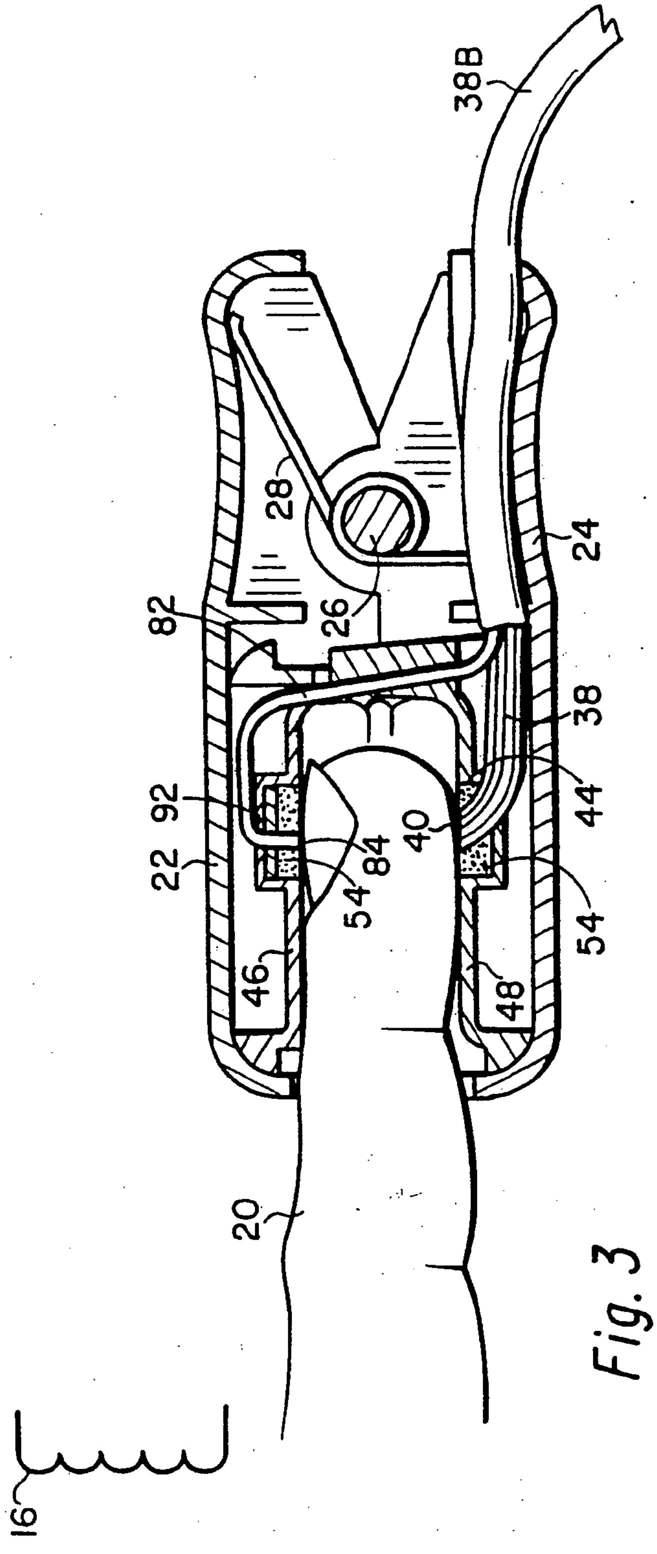

Fig. 3

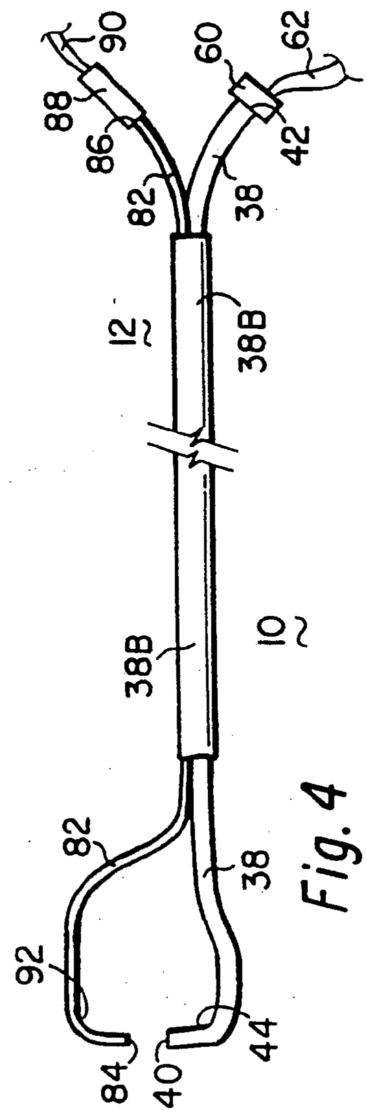

Fig. 4

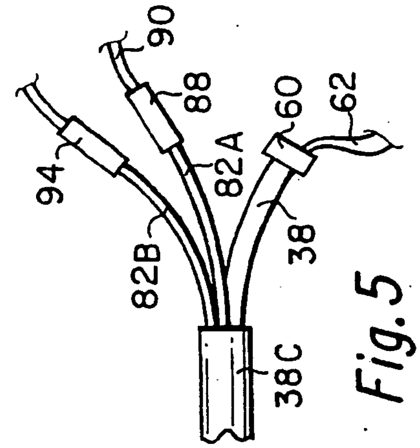

Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 92/04297

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 A61B5/00; A61B5/055

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	A61B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	DE,A,3 938 759 (PHILIPS PATENTVERW.) 29 May 1991	1-5,7--9
X	see column 2, line 26 - column 3, line 21	11,12
X	see column 4, line 37 - column 5, line 66	14-20,22
	see column 7, line 17 - line 23; figures 1,4,5	

X	US,A,4 506 626 (R.H. SCHURMAN) 26 March 1985	1,2
Y	see column 6, line 26 - column 7, line 40	9,10,19
A	see column 9, line 67 - column 10, line 44	6,8,12
	see figures 1,2,10-13	

Y	EP,A,0 262 779 (PHYSIO-CONTROL) 6 April 1988	9,10,19
A	see page 10, line 30 - page 12, line 9	1,3,6,8
A	see figures 11,12	14-17,22

A	US,A,4 380 240 (F.F. JÖBSIS) 19 April 1983	1-4,7,9
A	see column 5, line 65 - column 6, line 50	11,12
A	see figures 1,6,12	15-17,20

° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
02 SEPTEMBER 1992	24. 09. 92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	RIEB K.D.

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. US 9204297 SA 60792

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 02/09/92
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A-3938759	29-05-91	EP-A- 0430340	05-06-91
		JP-A- 3173536	26-07-91
US-A-4506626	26-03-85	None	
EP-A-0262779	06-04-88	US-A- 4913150	03-04-90
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		US-A- 4510938	16-04-85

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

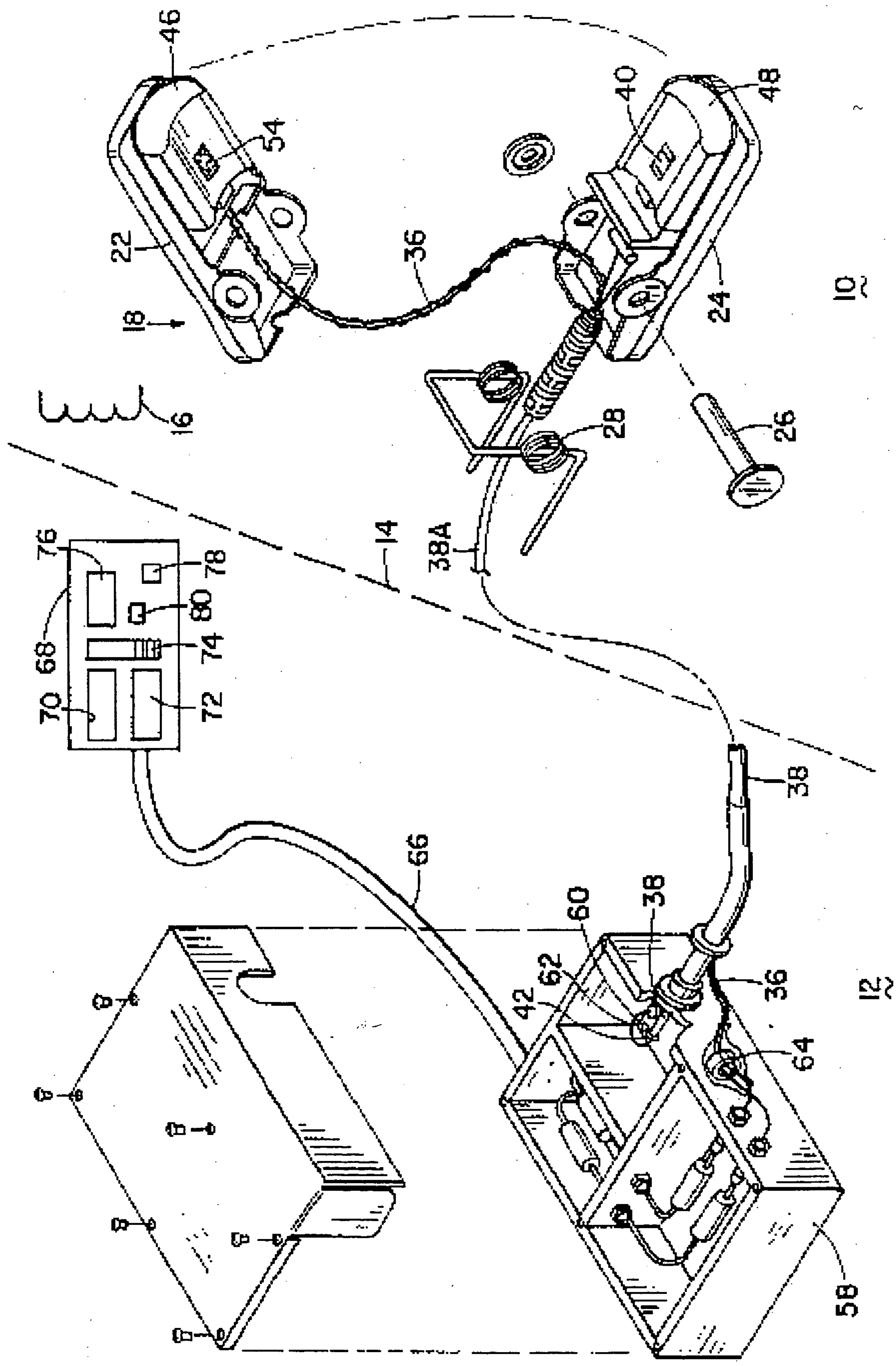
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Fig. 1

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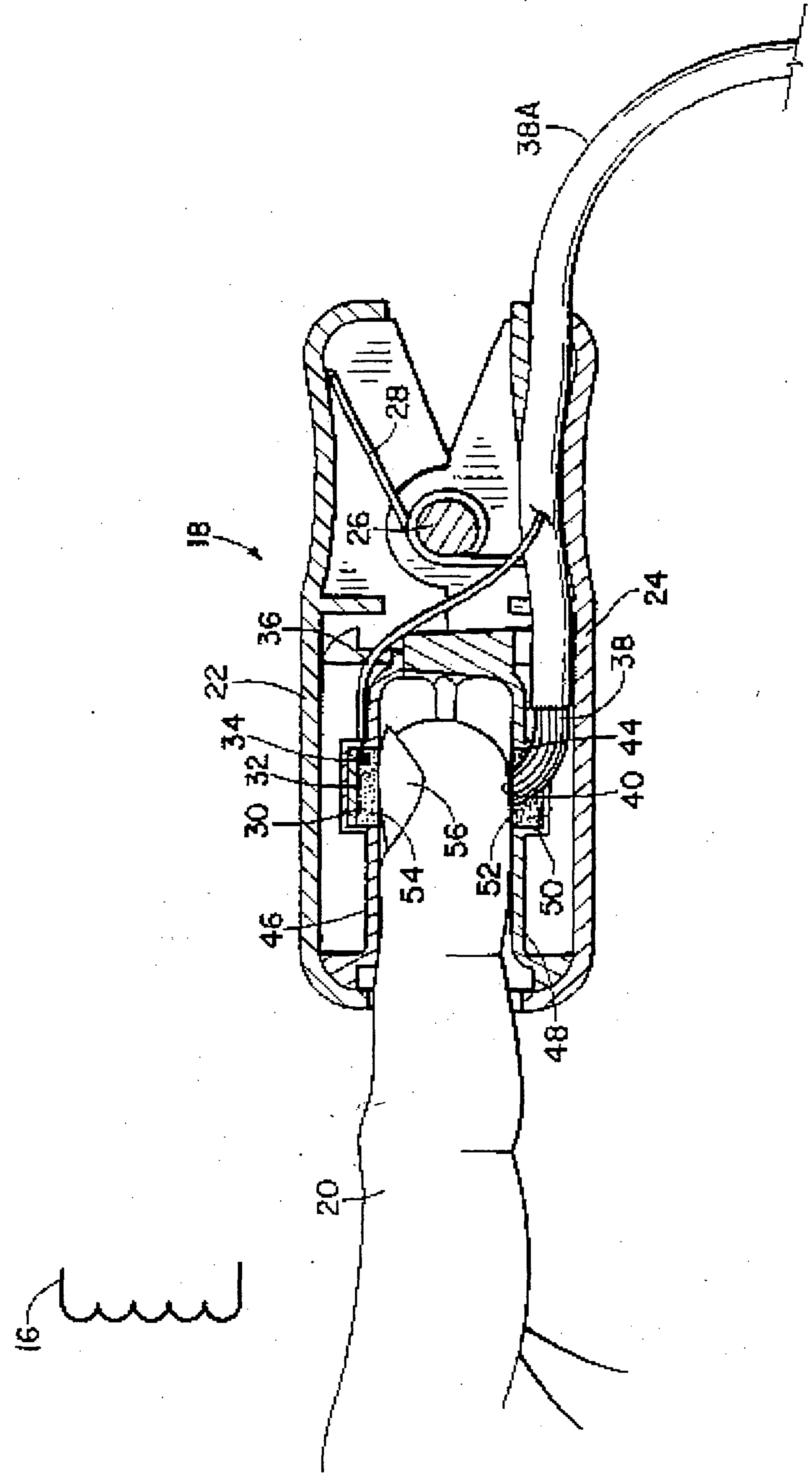

Fig. 2

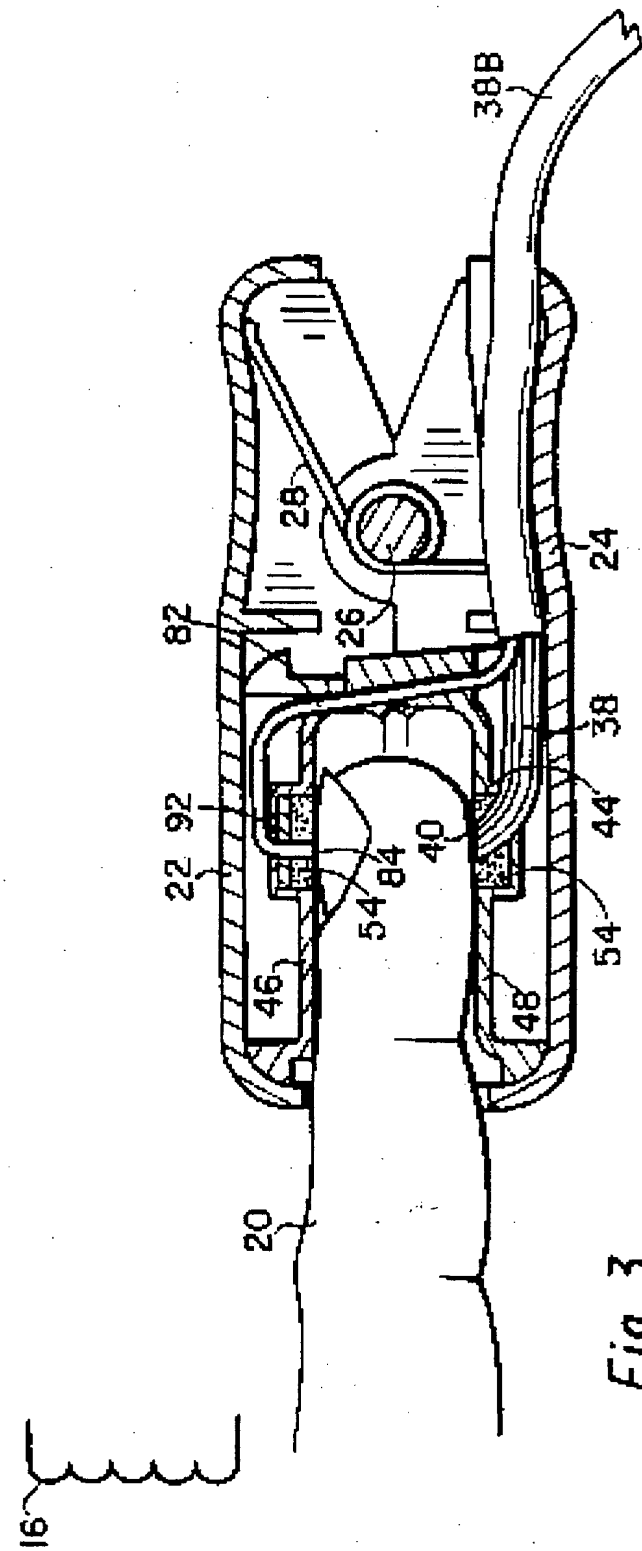

Fig. 3

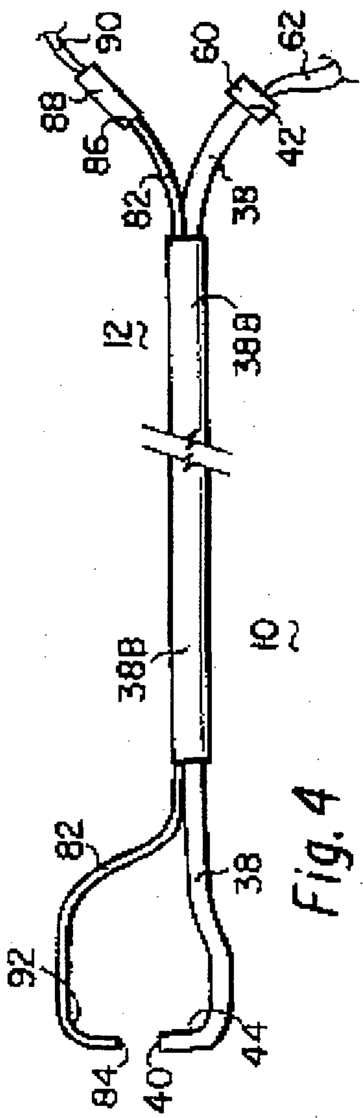

Fig. 4

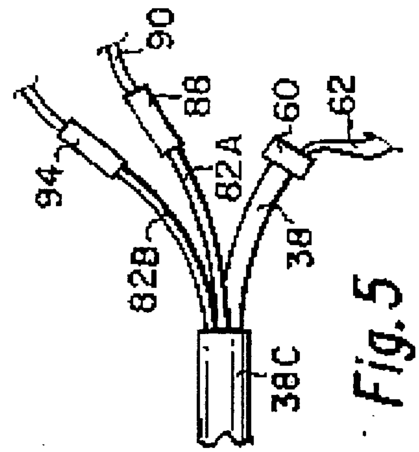

Fig. 5